Jack Ramsay, who has written extensively in this field, discusses in this issue the contributions of Oliver Lodge in "quasi-optics."

Lodge On "Quasi-Optics"

Sir Oliver Joseph Lodge (1851–1940) was the originator of the adjective "quasi-optical" for those microwave techniques which simulate optical phenomena. He himself demonstrated quasi-optical experiments at his memorial lecture on "The Work of Hertz and his Successors" in 1894. Lodge was especially familiar with Hertz' work as he had translated Hertz' papers for publication in "Nature," and admired his quasi-optical experiments.

We think it worthwhile to give a note on Oliver Lodge in view of the recent revival of interest in "quasi-optics," which is now generating new trends and techniques. Lodge is peculiarly suited to be the father of techniques which are partly electrical and partly optical, for he made several contributions of a fundamental character to the hybrid subject. He devised and named the "coherer," which was a point contact rectifier. He made the first waveguide radiators by enclosing a spark gap in a tube with one end open. He was an authority on resonance and invented "tuning." He made resonant cavities with radiating irises. He made the first microwave lens using pitch as the material.

For the quasi-optical experiments Lodge also constructed reflectors of different materials, made a paraffin prism, an Arago disc, a diffraction grating, polarization grids, and a zone plate. Thus he had the equipment for the quasi-optics—spark generators, point-contact rectifiers and galvanometers, wave-launchers in the form of waveguide and lens antennas and a variety of components based on the optical devices.

The quasi-optical experiments demonstrated by Lodge included the following:

1. *Radiation from a spark-excited waveguide to a waveguide receiving antenna containing a coherer.*

The wavelengths used were 3 inches and 7 inches. The directivity of the waveguide antennas was shown. Attenuation of the transmitter was demonstrated by stopping down its waveguide radiator by irises. In a polarization experiment the coherer was placed axially instead of transversely and "had the advantage of doing away with the polarizing, or rather analyzing, power of a crossway tube." Lodge had discovered TE and TM waves by accident. Note he also used "integrated antennas" as we now call them.

2. *Measurement of Reflection Coefficients*

Using his spark transmitter, coherer detector and the waveguide antennas, Lodge set up various sheets of material and radiated microwaves at 45° to the sheets. On the receiving galvanometer he measured the reflection. Numbers were obtained for window glass, a drawing board, a wet towel, lead foil, tin foil, and sheet copper. Even a human body was used as a target too! The reflection coefficient was second to the lowest—the glass.

3. *Measurement of Refraction by a Prism*

The paraffin prism was about a cubic foot in volume and had angles of 75°, 60° and 45°. Refraction was demonstrated.

4. *Focusing by a Lens*

In his 1894 lecture Lodge demonstrated with a 9 inch glass lens which he first set up optically by the light of a taper. The increase in output at microwaves due to the lens was demonstrated. In 1889, however, he had made a 1-meter square lens of pitch weighing 336 pounds. The wavelength then used was 101 cm and the results were less successful than at shorter wavelengths.

5. *Demonstration of Quasi-Optical Diffraction*

For the "bright spot" experiment an 18-inch circular copper disc was used successfully. The diffraction grating had copper strips 2 inches broad and 2 inches apart, but results were not satisfactory due to room reflections. The zone plate, of tin foil on glass, did not work very well either (Lodge's contemporary, Chunder Bose, however, could measure wavelengths accurately at microwaves using a diffraction grating).

Lodge's attitude to the classical diffraction is strange today. He said "Really there is nothing of much interest in diffraction effects, except in the demonstrations of the waves and the measure of their length . . . their theory is worked out. More interest attaches to polarization, double refraction and dispersion experiments."

6. *Simulation of the Nicol Prism Polarimeter using Wire Grids*

The transmitter and receiver waveguide antennas were fitted with polarization filters made of copper wire grids, and arranged to be cross-polarized. The insertion of a third grid, with its wires at 45° between the two crossed grids, restored "some of the obliterated effect" due to the initial cross-polarization. This was Hertz' famous analog experiment of the nicol, repeated by Lodge at a shorter wavelength.

7. *Demonstration of Brewster Angle*

Lodge used the largest face of his paraffin prism as a dielectric interface, and using the transmitter, receiver, and grids, showed that "when light is reflected from the boundary of a transparent substance at the polarizing angle, the electric vibrations of the reflected beam are perpendicular to the plane of reflection." With the electric vibration perpendicular to the plane of incidence, "plenty of radiation" was reflected; with the vibration parallel to the plane, "hardly anything" was reflected.

Many other followers of Hertz were to make even more striking "quasi-optical" experiments, but Lodge made a convincing start.

Reference

Lodge, O. J., "Signalling Across Space Without Wires," published by The Electrician Printing and Publishing Company, London, England, 1899.